Eclipse Drive Train for Windmill

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ABSTRACT : *The failure of conventional gearbox (constant mesh) is mainly due to shearing of gear teeth in contact, which is eliminated by using kinematic linkages in eclipse gear box. The force which is transmitted from the input shaft to the output shaft, which is mechanically coupled to rotor of the generator, is uniformly and equally distributed by the number of links present in eclipse gear box. The requirement of only one stage instead of multiple stages in conventional gearbox for complete transmission of power improves the reliability of the gearbox. For useful electricity generation constant output shaft speed is required which is achieved by eclipse drive train.*

Keywords *– Kinematic linkages, Single stage, reliability, Constant output shaft speed.*

I.   INTRODUCTION

The fastest growing renewable energy source is wind power. Wind power is currently responsible for about 1:5% of the world's electricity use. Because of this high interest in wind energy, it becomes more and more important to increase the efficiency of wind energy conversion systems, also called wind turbines. The complete system required to convert the energy in the wind to electricity is called a wind energy conversion system . Such a system consists of a rotor to capture the energy in the wind, a gearbox configuration to speed up the rotational speed of the shaft and a generator to convert the mechanical energy into electrical energy. The efficiency of the total system is not only determined by the efficiencies of the gearbox and generator, but also by the amount of energy that can be extracted from the wind [1]. The wind turbine works in three regions as shown in Fig. 1 In the first region the wind speed(0-4 m/s) is not sufficient to rotate the rotor of the wind turbine and it does not produce power. If connected to the grid the generator would act as a motor and the turbine would act as a fan.
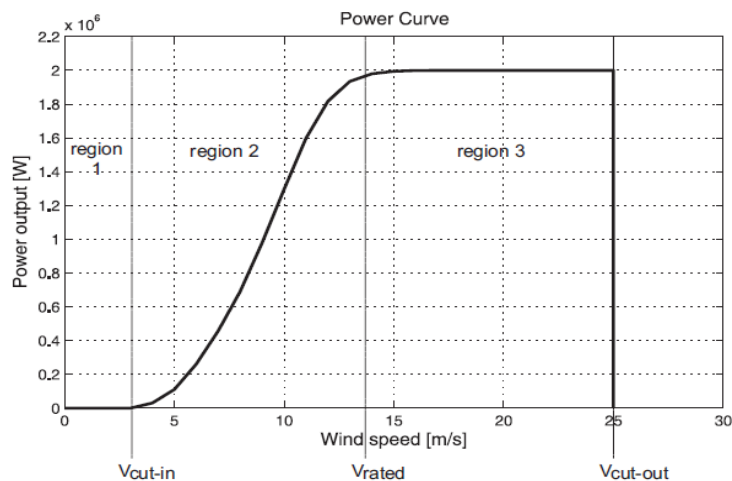

Fig 1, Operating regime of a wind turbine

The second region, region 2 (wind speed 4 to 14m/s), is the region between the wind speed at which the turbine starts to operate (V_{cut-in}) and the wind speed at which maximum power is produced (V_{rated}). This is the region for which maximizing energy capture is very important, but limitation of dynamic loads also becomes more important [2].In a typical wind turbine, region 2 operation accounts for more than 50% of the annual energy capture. This indicates the importance of efficient operation in this region. The third region (wind speed 14 to 25m/s) is from the rated wind speed to the wind speed at which the turbine is stopped to prevent damage (Vcut-

out). In this region, energy capture is limited by pitching the rotor blades such that the turbine and generator are not overloaded and dynamic loads do not result in mechanical failure.

II.   CURRENT SCENARIO

Variable speed operation of the generator results in the production of current with a variable frequency. The frequency of the produced current is determined by the electrical angular speed of the generator. For the electrical grid to remain stable, the frequency and phase of all power generating units must remain synchronous within narrow limits. When the frequency of the generator varies too much, in the order of 2 Hz, circuit breakers cause the generator to disconnect from the system, preventing damage to the grid. However, small deviations in the generator frequency can indicate instability in the grid. Power electronics is a technology that is developing rapidly. Higher current and voltage ratings are available, efficiency increases and costs decrease. Therefore, power converters are widely used in the wind turbine industry to improve the performance of wind turbines. However, there are also a number of disadvantages of using power electronics.

2.1   Disadvantages of Power Electronics

The biggest disadvantage of power electronics is reliability. Mechanical components show wear & tear and therefore any failures in these components can be predicted, maintenance can be scheduled before failure occurs. Unfortunately power electronics do not show signs of degrading, therefore failures cannot be predicted and these sudden failures are very expensive to repair. Together with high failure costs, power electronics tend to fail quite rapidly because they are very sensitive to voltage spikes .In the wind energy industry about 25% of all failures is due to the power electronics.

III.   SOLVING POWER ELECTRONICS PROBLEM USING ECLIPSE DRIVE TRAIN

The gearbox is prone to failure in the force transmission path between the turbine and the generator. Conventional wind turbine gearboxes use multi-stage planetary system. Eclipse drive train has a shortened force transmission path through a single stage of gears combined with linkages and a crankshaft. The linkages are designed to maintain evenly distributed linkage loads throughout the Eclipse system, irrespective of the loads applied to the input shaft. The gear loads are distributed over multiple bearings. The bearings in the linkages rotate partially. Only the bearings on the crankshaft and the alignment bearings for the high and low torque shafts rotate a complete 360 degrees. A thumb rule in gearbox design for energy loss through gear tooth contact is approximately one half of one percent (1/2 of 1%) for every stage of gear interaction that the energy passes through. The eclipse drive train designed has only two stages instead of six hence the energy loss is minimum. The results for a two link eclipse drive train (Table 4.1), show constant output speed for a variable input, which simulates the variable speed conditions during actual running. This increases the power generation range and reduces the need of pitching of blades.

IV.   RESULTS

The result shows that for input speed variation from 100 to 200 the output speed varies by 0.9 rpm.

Table 4.1

Input speed (rpm)	25	50	75	100	125	150	175	200
Output speed (rpm)	0.4	0.9	1.1	2.2	2.4	2.5	2.8	3.1

V.   CONCLUSION

The variation of input speed has little effect on the output speed which helps in increasing the region two shown in Fig. 1, thus the rated output speed is achieved faster. The windmill can thus be used at

rated speed for a longer duration annually. As the stages and contact points are reduced, the efficiency and reliability increases.

REFERENCE

[1]   Renewable Energy *World: http//www.renewableenergyworld.com/rea/news.*
[2]   M. J. Verdonschot Modeling and Control of wind turbines using a Continuously Variable Transmission, *DCT 2009.028.*
[3]   J. K. Gupta and R.S. Khurmi , Machine Design , *S. CHAND Publcation, 2011.*
[4]   P. S. G. Design Data , *P. S. G. College Of Technology, Kalaikathir Achchagam, 2005.*